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BUDDING AND GRAFTING TRIALS WITH COTTON AND RELATED PLANTS

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INTRODUCTION

Experiments with the budding and grafting of cotton have been made by several investigators during the last few years. The results of these experiments have shown that plants of different varieties and species of Gossypium can be budded and grafted successfully. Such asexual propagation is of value in preserving characters that might be lost in sexual reproduction.

The reports so far reviewed deal with the budding and grafting of closely related varieties and species of Gossypium. Experiments conducted by Meade (*1*)[1] at San Antonio, Tex., indicate that he encountered no difficulties in budding American upland cottons on the Asiatic types or vice versa. C. G. Marshall,[2] at Jackson, Tenn., budded several varieties of upland cotton and an Asiatic variety on a *G. barbadense* plant. Rea (*10*), at Temple, Tex., conducted a series of grafting experiments with upland cotton and reports that 46.2 per cent of the grafts were successful. McNamara and Hooton,[2] at Greenville, Tex., budded the *hirsutum* type on the *barbadense* type and made reciprocal buddings. Harland (*8*), at Trinidad, in 1917 found that "the West Indian perennial, or tree cotton (*G. purpurascens*), was an exceptionally good stock for Sea Island cotton." He also reports that successful results were obtained by using the "bottle grafting" method of propagation.

During the last three years budding and grafting trials have been conducted at the United States Acclimatization Garden, near Bard, Calif., between widely different species of Gossypium, including *G. arboreum*, *G. calycotum*, *G. cernuum*, *G. davidsoni*, *G. hirsutum*, *G. intermedium*, *G. peruvianum*, *G.* "*punctatum laciniatum*,"[3] *G. sturti*,

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[1] Italic numbers in parentheses refer to Literature Cited, p. 13.

[2] Unpublished data.

[3] Received under this name, but is not *Gossypium punctatum*.

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and several unnamed types, and between the genera Gossypium, Thurberia, Paritium, Hibiscus, Thespesia, and Erioxylum.

These studies were begun in the spring of 1929 and continued throughout 1930 and 1931. The climatic conditions at Bard afford exceptional opportunities for work of this character, as the winters are, as a rule, sufficiently mild to permit continuous growth of the plants throughout the year. The T type of budding and the inarch type of grafting were employed. The budding trials were made during the spring and summer months, and 38.1 per cent were successful. The inarch grafting was done during the summer and fall months, and 73.4 per cent of the grafts were successful. The small proportion of successful trials with budding is believed to be due largely to poor technic rather than to the method or to incompatibility of the plants.

In view of the fact that successful cross propagations were made among such widely diverse types, it is to be expected that no real difficulties would be encountered among any of the species or varieties of the cultivated cottons, even in cases where failures are recorded for the single attempts that were made in these experiments.

DESCRIPTION OF SPECIES

In order that a clearer understanding may be obtained of the wide differences in the species of Gossypium and related genera used in these studies, brief descriptions and photographs[4] are given here of some of the types that deviate greatly from the commercial varieties of the Asiatic, *Gossypium barbadense*, and upland groups.

Gossypium davidsoni Kellogg is a native of Lower California and Mexico (*12*). The plants are somewhat prostrate in type, with entire leaves, about 2½ to 3 inches long and 2 inches broad, pale green, with a dense covering of very fine hairs. Flowers are medium in size, pale yellow with dark-red petal spots. Bolls are rounded, about 1 inch long, three-fourths inch in diameter, and divided into four or five carpels. Seeds dark brown, practically naked. (Fig. 1, A.)

Gossypium sturti F. Muell., also referred to as *Sturtia gossypioides* R. Brown, is a native of Australia (*12*). The plants are tall and very ornamental in appearance. Leaves are entire, rounded in shape, 2 to 2½ inches long and about 1½ inches broad, whitish green in color. Flowers are medium size, rose purple with large dark-red petal spots. Bolls are divided into four or five carpels. Seeds are practically naked, small, and greenish brown in color. (Fig. 1, B.)

Gossypium morrilli Cook and Hubbard is a comparatively newly named species of cotton, introduced into the United States in 1925. The species was collected in Sinaloa, Mexico, by Cook and Hubbard and was fully described by them (*4*, *5*). A brief description based on theirs (*4, p. 339*) is as follows:

> Tall plants bearing numerous long, short-jointed fruiting branches with 10 to 12 nodes, often maturing bolls at each node, and frequently two bolls from the same node; leaves large, dark green, with very broad lobes, strongly up-folded at the sinus; involucral bracts broad; flowers white; bolls small, conic-ovoid, with a long acuminate point, mostly with 3 locks, but often with 4; seeds very small, black, naked except a small tuft of greenish brown fuzz at base; lint sparse, about seven eighths of an inch in length.

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[4] The photographs illustrating this circular were made by A. D. Harvey.

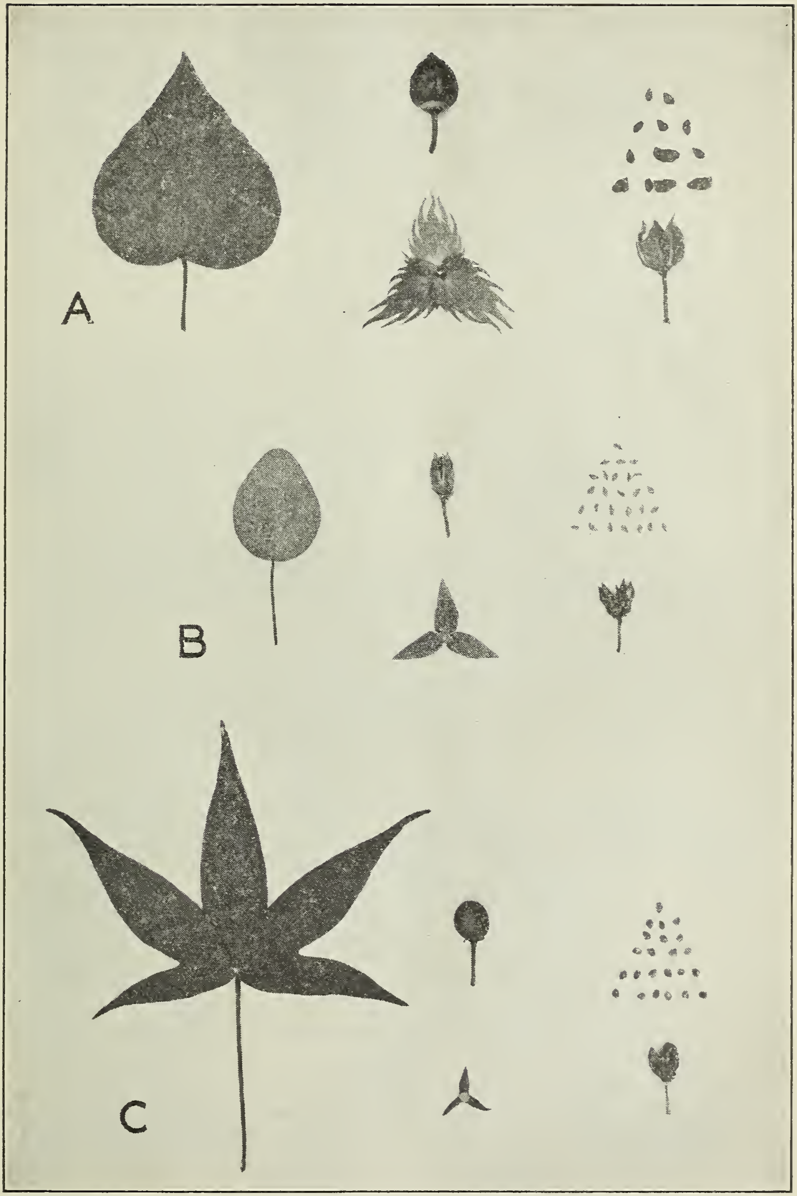

FIGURE 1.—A, *Gossypium davidsoni;* B, *G. sturti;* C, *Thurberia thespesioides*

Figure 2, B, shows the mature leaf, bolls, seeds, and seed cotton from plants grown at Bard, Calif.

Gossypium calycotum Cook and Hubbard was introduced into the United States by Cook and Hubbard in 1926 from Ecuador and was fully described by them (*6, pp. 550–551*). A summary of their description is as follows:

> Plants large, spreading, 8 to 10 feet high, the large fruiting branches with long basal joints like Egyptian cotton, though the foliage appears more like Upland cotton. Leaves light green, simple or 3 to 5 lobed, the upper surface subglabrous, the lower surface rather densely covered with very short stellate or tufted hairs; * * *. Involucral bracts large, with 10 to 13 rather large teeth; * * *. Flowers not seen. Bolls of medium size, attaining 5 cm. long, rather broadly conic-ovoid, with stout acuminate points, the surface rather closely and irregularly pitted; locks 3, with 9 or 10 seeds per lock. Seeds dark brown, with a small tuft of light brown fuzz at base. Lint white, about 1¼ inches long.

Figure 2, A, shows the mature leaf, seeds, and seed cotton from plants growing at Bard, Calif.

Paritium tiliaceum St. Hil., also referred to as *Hibiscus tiliaceus* L., is a native of the West Indies. A single plant of this species has been grown at Bard for the last five years. The plant is about 8 feet high and rather spreading. A few flowers were produced in the summer of 1931, but no bolls were set. Figure 2, D, shows a tip of a branch with leaves and stipules. This species has been described as follows (*2, v. 3, p. 1487*):

> Round-headed tree, 20–30 feet high * * * lvs. round-cordate and short-acuminate, entire or obscurely crenate, hoary beneath: involucre persistent with the calyx, 10-toothed or -cut; fls. 2–3 inches long, yellow; seeds glabrous or very nearly so.

Thespesia populnea Sol. is found in tropical Asia, Africa, and islands of the Pacific. A plant of this species has been grown at Bard for the last two years. It is about 7 feet high, slender in type, with several small lateral branches. So far no flowers have been produced. Figure 2, E, shows a tip of a branch and a mature leaf. This species has been described as follows (*2, v. 6, p. 3332*):

> A small tree with the younger portions covered with peltate scales; lvs. long-petioled, ovate, cordate, acuminate, 3 inches across; fls. axillary, 2–3 inches across, yellow.

Erioxylum aridum Rose and Standl. was obtained from Sinaloa, Mexico. A plant of this species has been grown at Bard for the last two years. It is of slender upright type, 9½ feet high, with several slender lateral branches. No floral buds have been produced up to the time of writing. A tip of a branch and a mature leaf are shown in Figure 2, C. The species has been described as follows (*11, p. 786*):

> Slender shrub or tree, 3 to 6 meters high; bark gray; leaves broadly ovate, 1.5 to 3 cm. long, acute or obtuse, rounded at base, sparsely and minutely stellate-pubescent; petals about 5 cm. long, nearly black within below the middle; capsule 2.5 cm. long. "Amapola."

Thurberia thespesioides A. Gray, a native of northern Mexico and Arizona (*12*), is under favorable conditions a tall shrub, with leaves palmately cleft into three or five parts; flowers small, white, with small pale-red petal spots; bolls small, about one-half to three-quarters inch long and one-half inch in diameter, divided into three

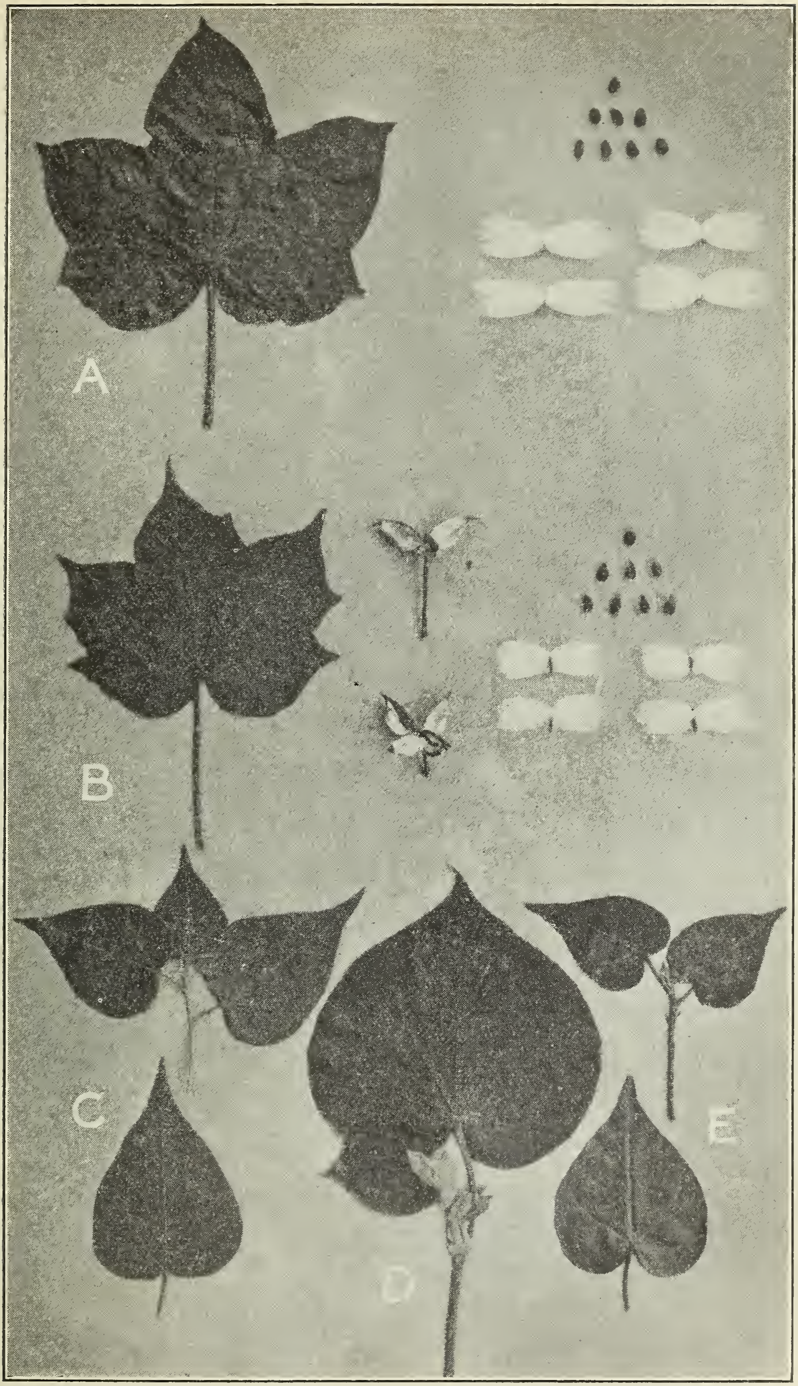

FIGURE 2.—A. *Gossypium calycoum;* B. *G. morrilli;* C, *Erioxylum aridum;* D, *Paritium tiliaceum;* E, *Thespesia populnea*

and occasionally four carpels. Seeds are small and have a coat of fine hairs. (Fig. 1, C.)

Attention has been drawn to Thurberia in Arizona because it was found to be the host of a native race of the cotton boll weevil (*3*). A later account of the Thurberia in Arizona was published by the Arizona Agricultural Experiment Station in 1923 (*7*). Numerous efforts have been made to cross Thurberia with the cultivated cottons, but thus far without success.

Mature leaves, bolls, seed cotton, and seeds of *Gossypium arboreum* L., *G. hirsutum* L., and *G. barbadense* L. are shown in Figure 3, for comparison with the widely different types shown in Figures 1 and 2.

Contrasting differences between the cultivated forms of cotton, wild species of Gossypium, and related genera have been described and illustrated by Watt (*12*) and Kearney (*9*).

BUDDING TRIALS

The budding studies were begun in March, 1929, when a single bud of *Gossypium arboreum* was inserted in a stock of *G. davidsoni.* This bud remained dormant for 13 months, showing the first sign of development in April, 1930. By the first of July it had developed into a branch 4 feet long and had produced a number of flowers and bolls. In the winter of 1930 the branch was pruned back within 2 feet of the stock. The following spring several lateral shoots were produced, which grew rapidly and produced another crop of bolls during the summer.

The same plant of *Gossypium davidsoni* was used in April, 1930, for budding trials with the following species: *G. cernuum* Tod., *G. intermedium* Tod., *G. sturti*, and *G. calycotum.* None of these buds developed, because a hot dry period following their insertion caused them to dry up before making a union with the stock.

In February, 1931, a *Gossypium sturti* bud was again tried on the same plant of *G. davidsoni* mentioned above. This bud remained dormant for five months, starting to grow the first of July, and within the next 40 days had developed into a branch 1½ inches long. Also, during February a bud of *Thurberia thespesioides* and a bud of *G. sturti* were inserted in the *G. arboreum* branch that had previously been budded on the *G. davidsoni* stock. The Thurberia bud developed rapidly, and by the last of June the resulting branch was 14 inches long and had produced a number of bolls. The *G. sturti* bud made a rather poor union and has developed very little.

The branches resulting from the buds of *Gossypium arboreum*, *G. sturti*, and *Thurberia thespesioides* growing on the *Gossypium davidsoni* stock are shown in Figure 4.

On June 5 a bud of *Thurberia thespesioides* was placed on a stock of *Gossypium calycotum.* A good union was established, and 40 days after the bud had been inserted it had developed into a branch 2 inches long with several leaves. On the same date an unsuccessful attempt was made to bud *G. intermedium* on *G. davidsoni*, and *G. calycotum* on *T. thespesioides.*

Six buds of *Gossypium hirsutum* (variety Acala) were inserted in a stock of *G. arboreum* on July 16, 1931. All these buds died with the exception of one, which started to grow 15 days later and by August 15 had developed into a small branch, as shown in Figure

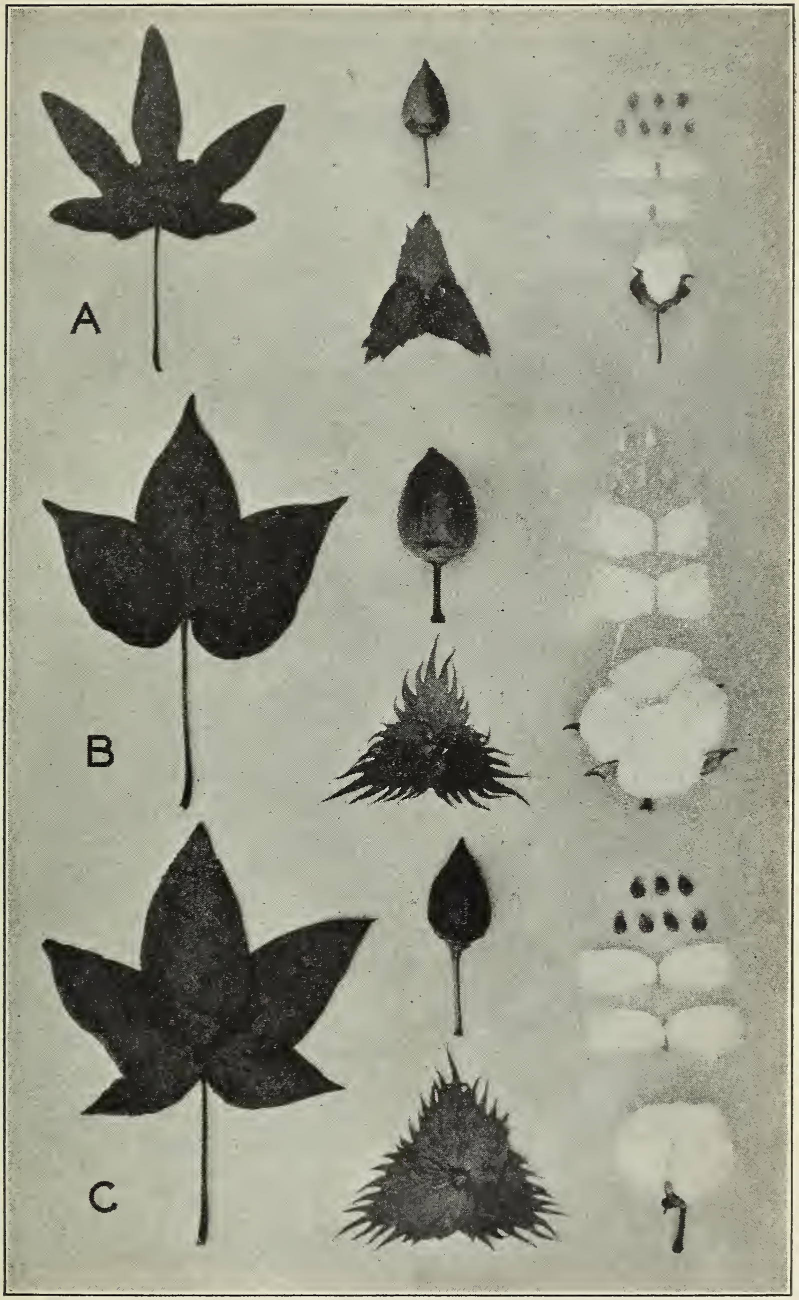

FIGURE 3.—A, *Gossypium arboreum;* B, *G. hirsutum;* C, *G. barbadense*

5, A. Two other *G. hirsutum* buds were placed on a plant of *G. peruvianum* Cav. One of these died. The other started growing promptly, and 30 days after it was placed it had developed into a healthy branch 2 inches long with several leaves. This bud is shown in Figure 5, B. one month after being placed on the stock.

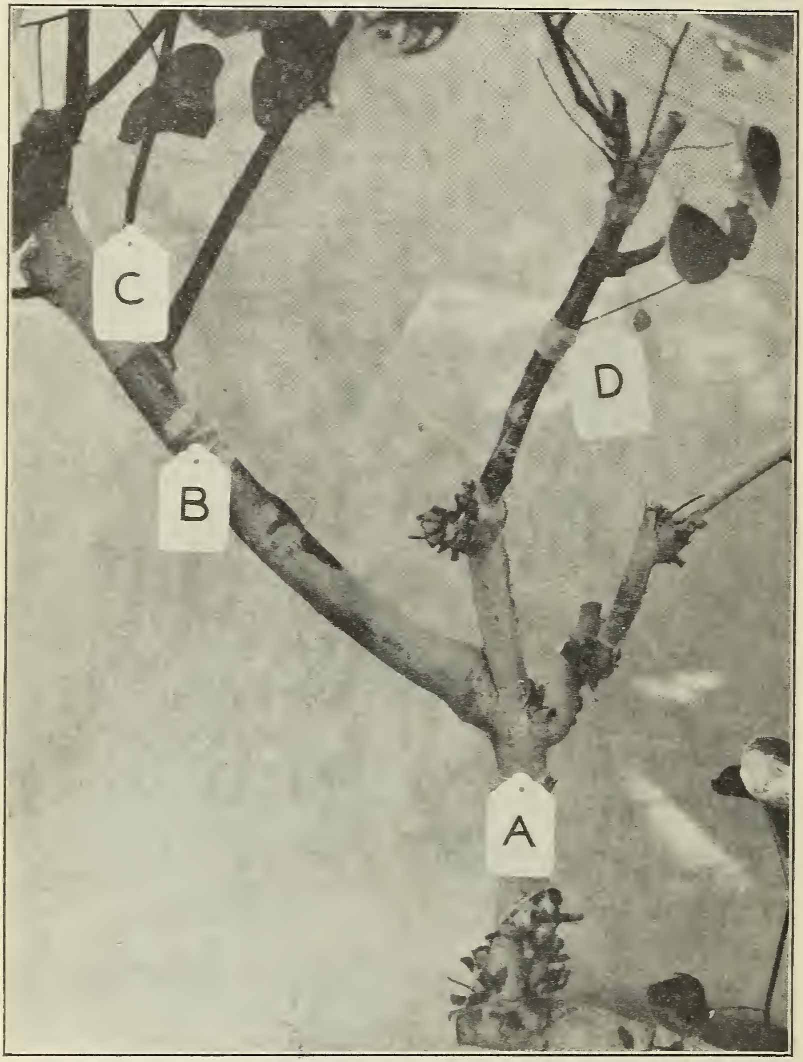

FIGURE 4.—Stock of *Gossypium davidsoni*, showing budded branches of (B) *G. arboreum*, (C) *Thurberia thespesioides*, and (D) *G. sturti*

Two buds of *Erioxylum aridum* were inserted in a plant of *Gossypium arboreum* on August 28. One of these buds lived, growing rapidly, and by October 3, 36 days after being inserted, it had developed into a branch 2½ inches long with several leaves. This branch is shown in Figure 6, 47 days after being placed on the *G. arboreum* stock.

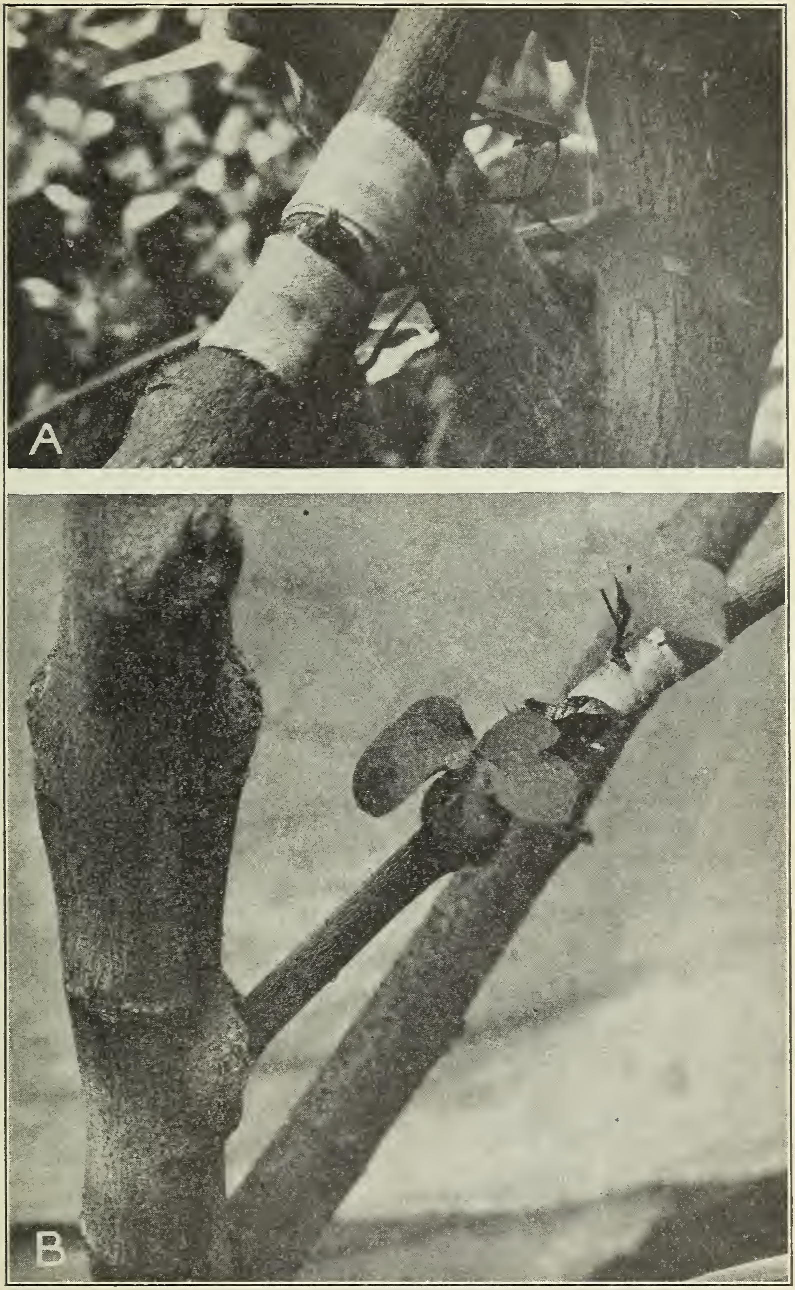

FIGURE 5.—A, *Gossypium arboreum,* showing bud of *G. hirsutum* (variety Acala) just starting to grow, 30 days after insertion; B, *G. peruvianum,* showing bud of *G. hirsutum* 30 days after insertion

The species of Gossypium and related genera used in these budding trials, the dates of budding, and the results obtained are given in Table 1.

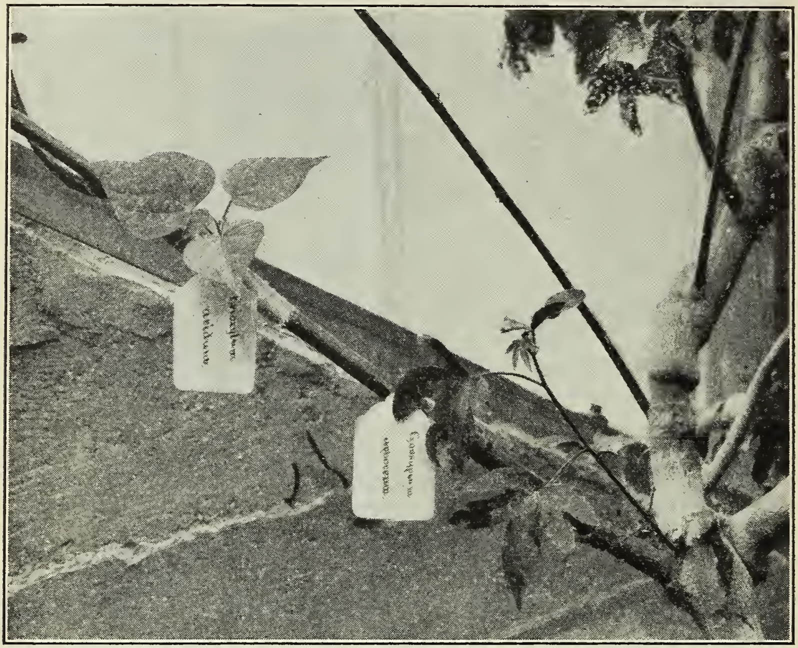

FIGURE 6.—*Erioxylum aridum* bud growing on a plant of *Gossypium arboreum*, 47 days after insertion

TABLE 1.—*Species of Gossypium and related genera used in the budding trials at Bard, Calif.*

Stock plant	Bud	Date of budding	Number of trials	Result
G. davidsoni	*G. arboreum*	March, 1929	1	Successful.
Do	*G. sturti*	April, 1930	1	Unsuccessful.
Do	*G. cernuum*	do	1	Do.
Do	*G. intermedium*	do	1	Do.
Do	*G. calycotum*	do	1	Do.
Do	*G. sturti*	February, 1931	1	Successful.
G. arboreum	do [1]	do	1	Do.
Do	*Thurberia thespesioides* [1]	do	1	Do.
G. calycotum	do	June, 1931	1	Do.
G. davidsoni	*G. intermedium*	do	1	Unsuccessful.
Thurberia thespesioides	*G. calycotum*	do	1	Do.
G. arboreum	*G. hirsutum*	July, 1931	6	Successful. [1]
G. peruvianum	do	do	2	Do.
G. arboreum	*Erioxylum aridum*	August, 1931	2	Do.

[1] *Gossypium sturti* and *Thurberia thespesioides* buds inserted on branch of *G. arboreum* growing on stock of *G. davidsoni*.

GRAFTING TRIALS

The first inarch grafting trial was made in August, 1930. In this trial a small plant of *Gossypium sturti* that had grown up beside a plant of upland cotton from Lower California was bent over and the cambiums of the two plants brought together for inarchment. The *G. sturti* plant was 14 inches high and one-half inch in diameter, and the upland cotton plant was 3 feet high and 1¼ inches in diameter. A good union was made within 30 days and the *G. sturti* plant was severed from its roots. The scion has remained in good condition, but has made very little growth. Neither the scion nor the stock was pruned back after the graft was made, and the stock continued to make rapid growth, which probably accounts for the slow development of the scion.

Branches of adjoining plants of *Gossypium* "*punctatum laciniatum*" and an upland cotton from Cambodia that had overlapped in the rows provided material for the second inarching trial. These plants were 1 year old and had made very rank growth, being about 8 feet high. The branches were inarched 14 inches from the tips, where they were about three-eighths inch in diameter. This inarch graft was made October 16, 1930, and a good union was established within 35 days, at which time the branch of *G.* "*punctatum laciniatum*" was severed from the mother plant. The scion grew very well, and by the first of August, 1931, had developed into a branch 3 feet long with several lateral branches. No fruiting buds have been produced by the scion, although a fair crop of bolls has been produced by the stock and the plant of *G.* "*punctatum laciniatum*" from which the scion was taken.

On October 16, 1930, a branch of *Gossypium sturti* was inarched with an overlapping branch of upland cotton from Siam, and a reciprocal graft was also made. The branches used in these grafts were three-eighths inch in diameter and about 8 inches long above the graft. Good unions were made within 35 days after the inarching, and the scions were severed from the parent plants. The upland scion grew rapidly and eight months after inarching had developed into a branch 2½ feet long. The *G. sturti* scion grew fairly well until the following January, when cold weather killed back the upland stock to a point below the inarched scion.

Two small *Gossypium hirsutum* seedlings (one Acala and one Okra-Leaf Acala) were set out beside a small plant of *G. sturti* in May, 1931, and were inarched with the latter July 20, when they were 14 inches high and three-eighths inch in diameter. Unions were established within 15 days, and the upland plants were severed from their roots, scions 8 inches long being left. All the leaves were removed from the scions, as they wilted badly after being severed. Both of these scions recovered and made rapid growth, and 45 days after inarching they were 14 to 16 inches long and had developed several small branches.

A branch of *Gossypium davidsoni* was inarched with a branch of *Paritium tiliaceum* on August 31, 1931. This inarchment was made with branches 30 to 32 inches long and about one-half inch in diameter. Sixteen days after the inarchment was made, the union appeared to be complete, but because of the large size of the branches the *G. davidsoni* branch was not severed until October 2. All the foliage was removed from the scion at the time it was severed. During the following two weeks several buds were produced and developed rapidly.

A series of inarch grafts was made September 16, 1931, when *Gossypium sturti* and *G. morrilli* were inarched with *Thespesia populnea*, and *Thurberia thespesioides* and an upland cotton from Mexico were inarched with *Paritium tiliaceum*. Unsuccessful attempts were made to inarch *Gossypium herbaceum* with *Hibiscus schizopetalus*, and *Thespesia populnea* and *Erioxylum aridum* with a species of Gossypium from the Galápagos Islands.

The inarch grafts of *Gossypium sturti* and *G. morrilli* with *Thespesia populnea* were made with branches 7 or 8 inches long and one-quarter inch in diameter. Good unions were established by October 2, 16 days after the grafts were made. The Thespesia branch that had united with *G. sturti* was cut off from its roots and continued to grow rapidly. Figure 7 shows this graft 16 days after it was made. The *G. morrilli* branch was severed from its roots on October 2. A small amount of the foliage was pruned from the scion, but no wilting occurred, and the scion continued to grow.

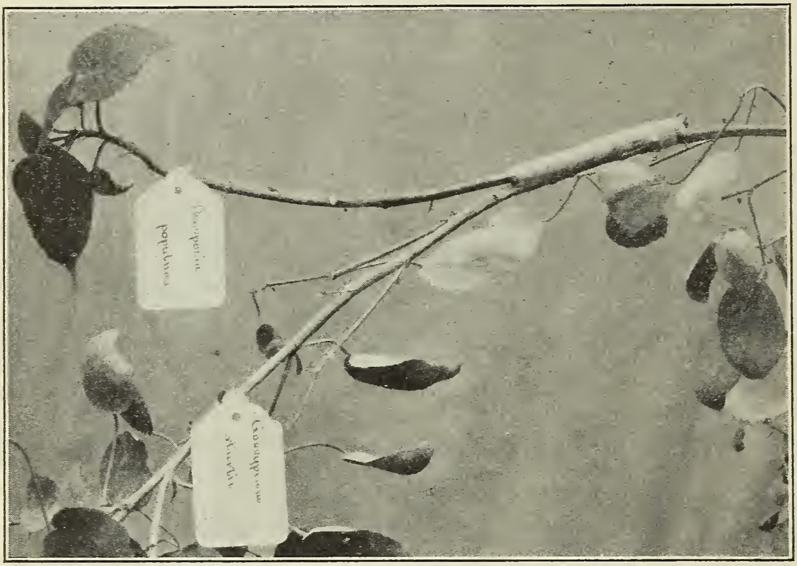

FIGURE 7.—*Gossypium sturti* with inarched branch of *Thespesia populnea*

The branches of Thurberia and the upland cotton from Mexico that were inarched with *Paritium tiliaceum* on September 16 made good unions and were severed from the parent plants 18 days after being inarched. Both of the scions were pruned back considerably because of the large amount of foliage above the unions. The remaining foliage never wilted, and the scions continued to grow, showing no effects of being severed from the parent plants.

None of the stock plants used in the inarch grafts were cut back, and their continued development, no doubt, retarded the growth of the scions to some extent. Although some of the scions have made fairly good growth, none of them has yet produced flowers; but branches of similar size and age on the scion-parent plants have set a good crop of bolls.

The species of Gossypium and related genera used in these inarching trials, the date of inarching, and the results obtained are given in Table 2.

TABLE 2.—*Gossypium and related genera used in the inarch grafting trials at Bard, Calif.*

Stock plant	Scion	Date of grafting	Results
Gossypium sp., upland type (Lower California).	*Gossypium sturti*	August, 1930	Successful.
Gossypium sp., upland type (Cambodia).	*G. "punctatum laciniatum"*	October, 1930	Do.
G. sturti	*Gossypium* sp., upland type (Siam).	do	Do.
Gossypium sp., upland type (Siam).	*G. sturti*	do	Do.
G. sturti	*G. arboreum*	do	Unsuccessful.
Do	*G. hirsutum* (Acala)	July, 1931	Successful.
Do	*G. hirsutum* (Okra-Leaf Acala)	do	Do.
Paritium tiliaceum	*G. davidsoni*	August, 1931	Do.
Do	*Gossypium* sp., upland type (Mexico).	September 1931	Do.
Do	*Thurberia thespesioides*	do	Do.
Thespesia populnea	*G. sturti*	do	Do.
Do	*G. morrilli*	do	Do.
Erioxylum aridum	*Gossypium* sp. (Galápagos)	do	Unsuccessful.
G. arboreum	*Hibiscus schizopetalus*	do	Do.
Do	*Thespesia populnea*	do	Do.

SUMMARY

The budding and grafting trials at the United States Acclimatization Garden, near Bard, Calif., show not only that widely different species of Gossypium can be successfully united by these methods, but that related genera also can be budded and grafted with species of Gossypium.

In these trials *Gossypium sturti* was successfully budded on *G. davidsoni* and *G. arboreum*, and inarched with upland types of cotton from Lower California and Siam. *Thurberia thespesioides* was budded on *G. arboreum* and *G. calycotum*. *Paritium tiliaceum* was inarched with *G. davidsoni*, Gossypium species of upland from Mexico, and *Thurberia thespesioides*. *Thespesia populnea* was inarched with *G. sturti* and *G. morrilli*, and *Erioxylum aridum* was budded on *G. arboreum*.

Twenty-one budding trials were made, of which 8 were successful, and 15 inarch grafts were made, of which 11 were successful. The low percentage of successful budding trials was, no doubt, due largely to poor technic. This is illustrated by the fact that of 6 *Gossypium hirsutum* buds inserted on *G. arboreum*, only 1 lived. Moreover, of the 2 *G. hirsutum* buds placed on *G. peruvianum*, only 1 lived; and of the 2 *Erioxylum aridum* buds inserted on *G. arboreum*, only 1 developed.

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